Push-pull-thinking

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Push – Pull - Thinking

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Abstract (max. 2000 char.):

Scientific innovation takes two distinct paths. Sometimes, companies ask researchers to develop a solution for a specific business problem. This is a demand-driven, "PULL" method. In other cases, scientists develop a technology with new valuable capabilities, and then search for commercial applications. This is a supply-driven, "PUSH" method. Whether innovation should be supply-pushed (based on the new technological possibilities) or demand-led (based on the social needs and market requirements) has been a hotly-debated topic. One point of view is that recognition of demand is a more important factor in successful innovation than recognition of technical potential. The alternative point of view is that the discovery of the new capabilities often leads to the more radical innovations.

This paper explains the key differences between the two methods and suggests how to setup the supply-driven technology commercialization path to improve its efficiency. It answers the following questions:

1. PUSH versus PULL: which innovation method is better for RISO?
2. How RISO can improve the success rate of its current PUSH method?
3. How to implement advice from this report?

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Scientific innovation using "Push" method

Scientific innovation takes two distinct paths. Sometimes, companies ask researchers to develop a solution for a specific business problem. This is a demand-driven, "PULL" method. In other cases, scientists develop a technology with new valuable capabilities, and then search for commercial applications. This is a supply-driven, "PUSH" method. Whether innovation should be supply-pushed (based on the new technological possibilities) or demand-led (based on the social needs and market requirements) has been a hotly-debated topic. One point of view is that recognition of demand is a more important factor in successful innovation than recognition of technical potential. The alternative point of view is that the discovery of the new capabilities often leads to the more radical innovations.

This paper explains the key differences between the two methods and suggests how to setup the supply-driven technology commercialization path to improve its efficiency. It answers the following questions:

4. PUSH versus PULL: which innovation method is better for RISO?
5. How RISO can improve the success rate of its current PUSH method?
6. How to implement advice from this report?

Question 1: PUSH or PULL?

First, some key notions. What is "scientific innovation"? Innovation is invention plus commercialization. Invention is a process of matching a problem and solution, while commercialization is a process of putting the invention into a wide-spread use. Innovation is scientific if scientific expertise is critical to finding a solution (as opposed to business, engineering or design expertise). Any innovation involves deep knowledge of both a problem and a solution. If researchers learn a customer problem first, and then search for a solution, this is PULL method. Under this method, commercial applications are known before technology is developed. If researchers develop new technological capabilities first, and then search for problems they can solve with them, this is PUSH method. Under this method, commercial applications are known after technology is developed.

Which approach is a better way to innovate? In my opinion, this is the wrong question. Instead, we should ask: what are the advantages and disadvantages of each approach, and how to use both methods properly to maximize our chances to innovate successfully?

To answer these questions, recall that innovation can be viewed as a risk-reduction process (see "Innovation Report", p.12 to learn more). Every innovation opportunity contains various risks. At the early stage – invention - the main risks are technology-related and market-related. Technology risk is the uncertainty that we might be unable to find a solution. Market risk is the uncertainty that we might be unable to find an application. Since under PUSH and PULL methods innovation follows different paths, it will also have different composition of these risks. Under PULL method, market risk is lower because application is known, but technical risk is higher because solution is unknown. PULL method has the opposite risk profile: technical risk is lower, because we already have a solution, but market risk is higher, because we are yet to find applications.

To make an innovation successful, we must reduce these risks to the commercially-acceptable levels. Research institutions like RISO are especially good at reducing technical risks – they have highly qualified, multi-disciplinary group of scientists and modern research facilities. Unfortunately, the opposite can be said about RISO ability to reduce market risks. It does not possess deep knowledge of business and the skills and resources required to conduct high-quality market research. If we organize these conclusions into a table:

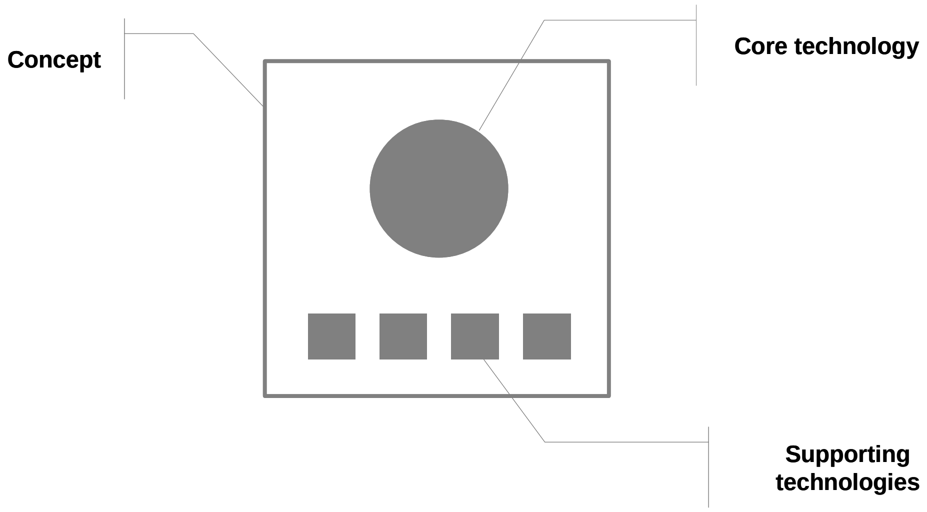
	RISK	
	Market-related	Technology-related
PUSH innovation	High	Low
PULL innovation	Low	High
RISO ability to reduce risk	Low	High

Table 1: RISO risk-reduction abilities versus PUSH/PULL risk profiles

we can see that RISO has higher chances for success with PULL innovations, because its capabilities match the risk profile of this approach. Indeed, R&D institutions like RISO have higher success rates with PULL innovations. PUSH innovation attempts result in many unlicensed patents, non-paying licenses and dead spin-outs. However, traditionally PUSH is the method of choice for the scientific community!

An interesting question is - why? Is this choice irrational, and should we make RISO innovation program 100% PULL-driven? The answer is No. Scientists preference for the PUSH approach is, indeed, partially irrational: many researchers are psychologically more comfortable working in the labs solving scientific problems than going out, mingling with business people and learning market problems. This choice is also largely defined by the way R&D institutions are set up: they pursue knowledge discovery, and scientific innovation is traditionally a byproduct of the research, not its primary objective. However, PUSH approach has full rights to exist because it has strong advantages over PULL method in certain situations - for example, when society and business have unrecognized, hidden needs, which can't be clearly defined as problems for PULL approach. Again, the real question is not which approach is better, but rather WHEN to use PUSH method, and HOW to use it properly.

When does PUSH approach have advantages over PULL method? To answer this question, I used TRIZ theory. TRIZ is a Russian acronym for the "Theory of Inventive Problem Solving". It was developed based on the analysis of more than 2,000,000 global patents, and it provides tools to classify inventions based on their significance (to learn more about TRIZ, visit www.triz.org). Imagine, that any invention can be presented as the following object:

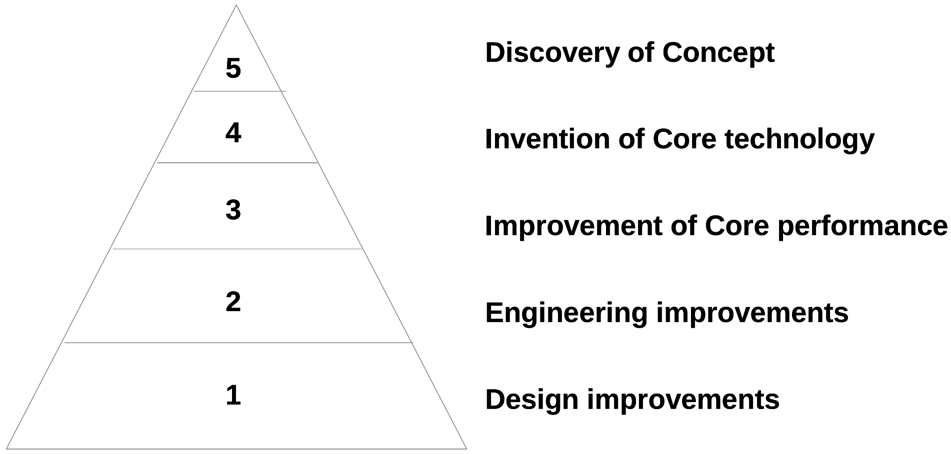


Picture 1: Abstract representation of an invention

This object consists of 3 key components:

- **"Concept"** - a general idea, a framework, such as "Computer", "Laser", "Automobile"
- **"Core technology"** - technology which is critical to enable the concept. If we don't know how to make the core, we can't make the concept work at all.
- **"Supporting technologies"** – components which are necessary, but not critical to enable the Concept.

For example, “Laser” is a concept which has a light-emitting element (Core) and a power supply and lenses (supporting elements). Using these definitions, we can classify all inventions on 5 levels:



Picture 2: Invention levels

Level 5: Creation of a new concept. Imagine, a researcher comes to your office, and says: “I discovered an interesting phenomena – coherent light. I call this new concept “laser”.

Level 4: Creation of a new core. Later, another researcher announces: “The recently discovered laser is based on the gas emitter. I found that semiconductors can also emit coherent light”.

Level 3: Improvements of the existing core. Another researcher says: “For the semiconductor laser invented by the previous scientist, I found a compound which gives 10 times more output”.

Level 2: Engineering improvements with supporting technologies. Later, an engineer says: “For your semiconductor laser, I can add special lenses, and output increases by another 20%”.

Level 1: Design improvements using supporting technologies. Finally, a designer suggests: “for this laser, I can design a better power supply, which is 2 times smaller and looks more aesthetic”.

Innovation potential rapidly increases with the level of invention. Level 1 invention can make company products more user-friendly and give it some marketing advantages. Level 2 allows it to become a leader of a niche market. Level 3 can dramatically increase its profit margins and give strong competitive advantage. Level 4 can give new generation of the product, and make the company its industry leader. Level 5 inventions can create new industries.

However, both market and technical risks, and commercialization costs are also increasing with the levels. If level 1 invention can be completed by one person in a garage on a personal budget, Level 5 inventions usually require multi-disciplinary global teams, decades of research and multi-million dollar marketing budgets. This fact is illustrated by the frequency of the patents on the different invention levels:

Invention level	Number of Patents
5	1%
4	4%
3	18%
2	45%
1	32%

Table 2: Frequency of patents on various invention levels.

Source: www.triz.org

If we combine TRIZ classification system with PULL and PUSH methods, we can define 10 possible innovation opportunities with distinct risk/reward profiles, and use these definitions to improve the quality of RISO opportunity evaluation decisions:

	PULL	PUSH
Level 5		
Level 4		
Level 3		
Level 2		
Level 1		

Table 3: 10 possible risk/reward profiles of innovation opportunities

Level 1 & 2 PULL and PUSH opportunities

Level 1 and 2 inventions, both PULL and PUSH, require no or little scientific knowledge. Level 1 is a design innovation, and Level 2 is an engineering innovation. Scientific innovations start from level 3, and science contribution increases with each level. In my opinion, RISO should not engage in Level 2 & 1 opportunities, because it does not have any advantage in design or engineering over the specialized companies like IDEO. In practice, RISO is going to see a lot of the innovation opportunities of this type, as byproducts of the research or cooperation with the small companies. Should RISO ignore them entirely? The best approach RISO can probably take is to establish long-term partnerships with the design and engineering companies in Denmark, and refer these opportunities to them (perhaps, for a small referral fee, or in exchange for help with the higher-level inventions). RISO should definitely avoid investing the spin-outs which are based on the Level 1 or Level 2 inventions. In most cases, the potential of these opportunities is too low to justify the spin-out costs, and chances for success are too slim.

Level 3 PULL opportunities

Level 3 PULL opportunities should be the bread and butter for scientific innovation. According to TRIZ, more than 90% of all innovation problems have already been solved by somebody, and we just need to find that knowledge. Unfortunately, such search requires deep and broad exposure to the multiple scientific disciplines. This is where RISO has strong advantage, and that is why these opportunities are the best fit: they have sufficiently high market potential, while RISO scientists have great chances to find an innovative solution using already existing scientific knowledge, without the need for the costly additional research. In many cases, a proof of principle can be demonstrated within a year or less. Level 3 PULL opportunities can be licensed, or spun out if there is enough market potential to set up an new company. Spin-outs based on this innovation class will have the highest chances to survive.

Level 3 PUSH opportunities

Level 3 PUSH opportunities are usually the worst candidates for innovation - they have modest market potential, but high market risk, and require significant amount of time, money, entrepreneurial skills and luck to find profitable applications. Unfortunately, this is the most frequently used approach by scientists - the vast majority of the university spin-outs are based on LEVEL 3 PUSH inventions. Their chances of success are very low – only 1 company out of 20 survives the first 3 years.

However, since Level 3 inventions represent improvement of the core technology, we can separate Level 3 Push inventions into 2 sub-classes, “a” and “b”, depending on the magnitude of the improvement. Sub-class “a” will contain inventions where improvement is radical – for example, 20 times gain in performance, or 10 times reduction of costs. “A”-type inventions have better chances to survive, if we assume that the large advance in technological capability has better chances to find profitable applications than incremental improvements. Such inventions might be good candidates for spin-out investments. Class “b” contains inventions with only incremental improvements, the vast majority of the Level 3 PUSH opportunities - over 90% of all cases. RISO should avoid investing in class b inventions – their competitive advantage is not enough to overcome the costs of commercialization.

What should RISO do with the Level 3 PUSH cases it rejects? In my opinion, the best strategy is to try to convert these cases into the PULL opportunities. Such conversion can be done using a very low cost 2-tier marketing program, similar to the approach used by Stanford OTL. First, RISO can create an email list for the companies and entrepreneurs, which they can subscribe to for an annual fee. Every month or quarter RISO can create a digest of all PUSH technologies it does not want to pursue (Levels 1, 2, and 3-b), and send it out to the subscribers. Here is an example of Stanford technology digest article:

> *"Superconductor Room Temperature Bonding Process"*
>
> *Stanford University scientists have discovered a superconductor bonding technology that promotes electronic superconductance. This "Super-C-Bond" is a room-temperature process that creates superconductivity-retaining joints for both low-Tc superconductors and high-Tc superconductors. This technology can be used for superconducting magnetic energy storage, superconducting cables for power transmission, superconducting RF Filter connections for cell phone communications, and superconducting magnet leads for magnetic resonance imaging. Here is a web link to an abstract describing the details and applications of the technology: http://availtech.stanford.edu/Scripts/otl.cgi/docket?docket=00-111. If you are interested in discussing this licensing opportunity or would like additional information please contact Irit Gal at 650-723-1586 or irit.gal@stanford.edu. Any feedback you have on this invention would be appreciated and we look forward to hearing from you in the next few weeks.*

The subscribers will have an exclusive period of 1-3 months to respond to the digest, with an option to get an exclusive license. If any subscribers respond and suggest an attractive and viable application, RISO effectively converted this PUSH invention into a PULL project, now driven by a customer. If paying subscribers forfeit their rights, RISO can create a second email list, which is open to anyone for free, and sent out after the exclusive period expires. Such system will give RISO maximum exposure, and help to propagate inventions among the entrepreneurs and small Danish businesses, who can't afford to pay high fees. If nothing eventually happens, RISO can just add the remaining inventions to its knowledge base.

Level 4 PULL opportunities

Level 4 PULL opportunities happen when a customer asks researchers to find a new paradigm for a core of an existing system. In this case, the potential is usually large and obvious (for example, fuel cells), but the chances and costs of finding a solution are more challenging than on level 3. Technical risks are the major factor, and research can take several years to find an acceptable solution. These opportunities are good candidates for the long-term research partnerships.

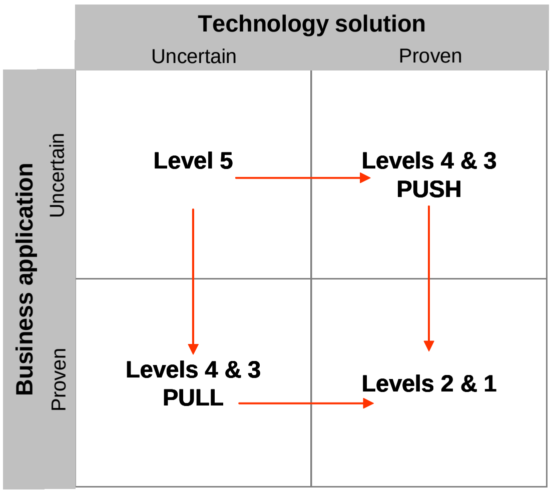
Level 4 PUSH opportunities

These inventions are usually new technological platforms. The good news is that each platform might allow building several businesses on the same intellectual property, effectively reducing technical risks and costs. The market potential of these opportunities is usually much higher than the commercialization costs, and they are good candidates for multiple spin-outs. Level 4 Push inventions have significantly more strategic flexibility than level 3 inventions, which improves spin-out chances for success. Level 4 PUSH opportunities are rare, and are worth a special effort to investigate them in depth.

Level 5 opportunities

Level 5 PULL opportunities don't exist by definition, because this level is based on newly discovered knowledge not yet absorbed by the society, and specific needs are not recognized yet. Level 5 PUSH opportunities are extremely rare – they represent less than 0.3% of all inventions. If such an opportunity appears, RISO should pay special attention and allocate extra budget to its investigation. In this case, huge potential justifies hiring market research experts to find the best applications. Like Level 4, Level 5 provides excellent candidates for multiple spin-outs. The key difference is that Level 4 has a much lower market risk, because at least one application already exists.

Finally, let us put invention risk profiles, TRIZ classification and PULL/PUSH paths on the same chart, to have a clear picture of how inventions evolve over time:

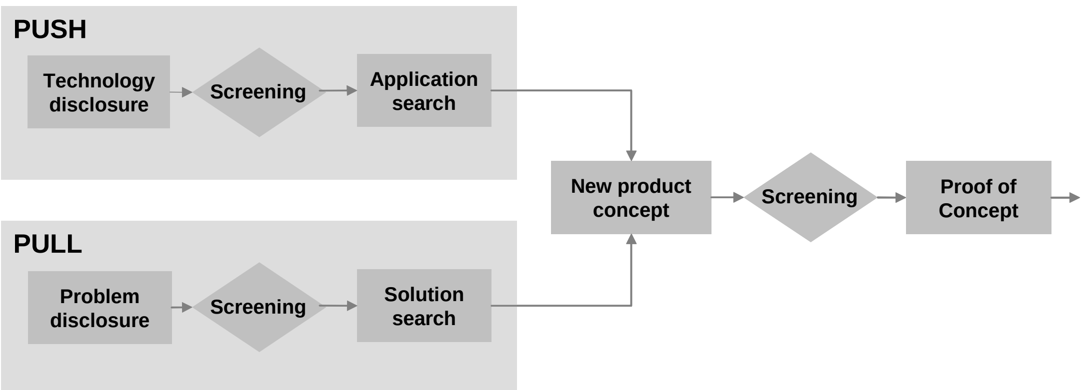


Picture 3: Evolution of inventions

All inventions start from level 5, and move down. Typically, every level 5 & 4 invention creates 64 level 3 inventions, and 1600 level 1 & 2 inventions. Periodically, a new core paradigm is discovered at level 4, and it creates an avalanche of the lower-level inventions. This process revolves until a level 5 invention makes the current concept obsolete.

Question 2: How can RISO improve its current PUSH efforts?

Although PULL opportunities are easier and have better success chances, RISO scientists will inevitably generate a large number of PUSH opportunities. Therefore, it is important to improve current PUSH process, to reduce unproductive expenses and increase success chances. This process must eventually generate a viable, high-potential product concept. At this step PULL and PUSH paths converge and thereafter opportunities can be processed in virtually the same way:



Picture 4: Key steps for PULL and PUSH paths, and their convergence

To commercialize PUSH technology, we must be able to handle 3 tasks as efficiently as possible:

1) Capture researchers knowledge about the new technology
2) Separate high-potential opportunities worth pursuing from the rest
3) Find viable business applications

Respectively, PUSH process consists of the three steps: Technology disclosure, Technology screening, and Application search. Let's consider each step separately.

Technology Disclosure

The purpose of the disclosure is to capture researchers knowledge about their invention in a way that can help innovation team evaluate the potential of the new technology. Essentially, it is an interview on paper. The disclosure form should contain the following information:

Category	Topics
Summary	▪ Brief description of new technology ▪ Value of the invention ▪ The history of the invention
Technical potential	▪ Detailed explanation of the novel principles ▪ Capabilities and limitations of the new technology ▪ Comparison to the world level/competing technologies ▪ Current status of the technology. What and when can be demonstrated? ▪ Remaining issues and estimated time to solve them
Business potential	▪ Known and potential applications ▪ Commercialization status (existing industry relations, demand evidence)
Intellectual property	▪ IP ownership ▪ Patent status
Project management	▪ Departments and researchers involved ▪ Researchers time availability for the innovation project
Information Resources	▪ Names of technical and industry experts who can help evaluate the invention ▪ Technology education resources (books, tutorials) ▪ Information sources (research papers, articles, links, etc)

The Disclosure should not be structured as a traditional form with boxes and fields, because it will be perceived as inflexible and bureaucratic. Instead, I suggest to make a list of questions with explanations what we want to receive. Also, we should make all answers optional, but explain that the more information we receive, the better decision we can make. Innovation team should train researchers to use the disclosures, provide examples and offer an easily accessible hotline to clarify possible questions. Please see a Technology Disclosure draft in Appendix 1.

After the disclosure is submitted, the innovation team should assign it to a project manager with the most relevant background. The manager must next complete 3 steps:

1. Learn the technology and the situation
2. Convert Disclosure information into a set of key facts
3. Conduct Due diligence to verify the facts

The goal of background education is to train project managers in the basics of the technology, terminology and state-of-art so that they are able to formulate intelligent questions for the due diligence. The managers should thoroughly study the disclosure, visit research labs and see the technology demonstrations, interview the researchers, and explore education resources mentioned in the disclosure.

Then, the managers must convert information from the disclosure into the facts and summarize them in the form called Opportunity Fact Summary. This form contains key factors needed to evaluate the opportunity and make a decision what to do with it. Please see the Opportunity Summary form in Appendix 2. After the form is filled, it should highlight critical gaps in the information we need, and the managers must find the missing data, either by working with the researchers, or conducting their own research. If during this process the manager decides that the technology it is not ready yet, she should request more development and put the invention on hold.

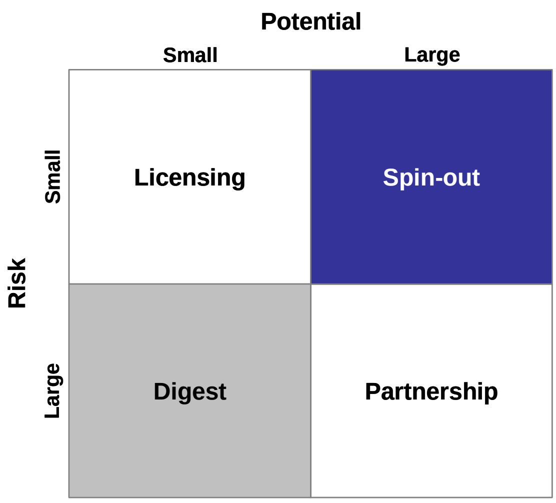
After the Opportunity Evaluation Summary is completed, we must conduct the due diligence. The objective of the due diligence is to verify researchers' claims, using independent technical and business experts, and library research. If due diligence findings contradict researchers claims, the manager should investigate the possible reasons and either resolve the conflict, or reject the Disclosure.

Technology Screening

After the facts are collected and verified, RISO team must decide what to do with the technology. How much time and money do we want to invest in it? What commercialization path has the highest potential and highest chances for success? If we want to continue with the technology, we have 4 possible ways:

1) Put this technology into the "Invention digest" and make it public
2) Actively search for licensees
3) Actively search for an industry partner for joint research & development
4) Issue innovation grant and consider a spin-out company incubation

How do we make this decision? The choice depends mainly on the combination of 2 factors: perceived potential of the technology, and estimated risk of our failure:



Picture 5: Selection of the technology commercialization path

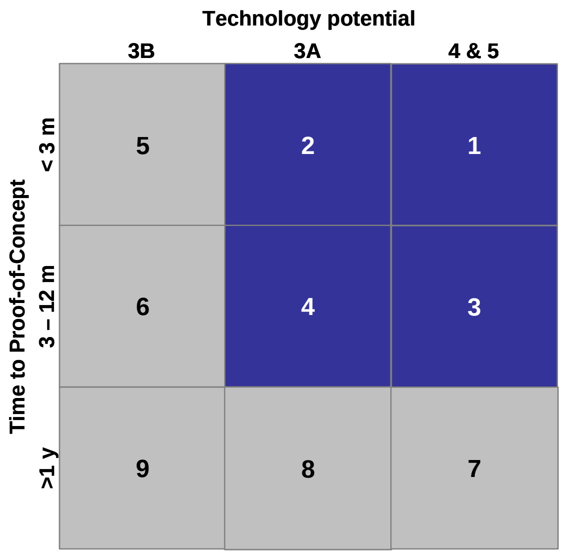
If technology potential is large, managers should consider spinning it out. Spin-out is the best option if it can be brought to the external funding within a reasonable budget and time (for example, less than $200,000 and 1 year). If the potential is large, but risk is too high or can not be judged properly, a research partnership might be a better option. If the potential is limited or unclear, but it can be brought to the "marketable" state within a reasonable time and budget, the best strategy is to actively search for licensees. Finally, if the technology potential looks weak, and its implementation challenges are high, we can put the invention into the "Invention digest" and make it public, in a hope to find somebody in a better position than RISO to take advantage of the invention. This decision process is general, and the actual choice might be different if there are other considerations. For example, even if the opportunity fits spin-out process requirements, licensing strategy might be selected if RISO already has relations with a strong, interested industrial partner who can offer RISO a reasonable deal.

It all sounds logical, but how do we estimate Potential & Risk?

Potential can be estimated fairly reliably using market research, if there is sufficient time and budget. Unfortunately, at the very early stages project managers usually have to use indirect clues. I suggest to use TRIZ classification described above to improve their judgment. The largest potential will have level 5 & 4 inventions, then 3A (radical improvements of the core), and the smallest - 3b (small improvements). Levels 2 & 1 should be excluded.

Risk can be estimated by planning resources (time and budget) required to develop a proof-of-concept from the current state of technology and market risks, taking in account project management issues. If scientists already can show a working technology, the risk is obviously much smaller than if they only have a theoretical idea. Required resources can be estimated from the number and complexity of unresolved issues. Project manager should ask researchers to develop a detailed list of tasks to be completed before the technology can be demonstrated. We can also simplify the task by assuming that the project time is a good indicator of risk. This assumption is reasonable if our main costs are compensation for the researchers time, while other costs (i.e., materials) are typical, nothing extraordinary. In this case, we can consider that short projects (say, less than 3 months) have the smallest risk, mid-term projects (3-12 months) - average, and long-term projects (1- 3 years) - the highest. Projects longer than 3 years represent too high risk for RISO and should be considered only as exceptions and only for long-term partnerships.

Putting the potential and risk estimates together, we can define a convenient framework to make decisions of what to do with the new technology:



Picture 6: Technology evaluation decision matrix

Quadrants 1, 2, 3, 4 are excellent candidates for spin outs. These opportunities will have exceptionally high chances for success, but they are rare, and RISO should have no problems building sufficient capacity to incubate them. Quadrants 7 and 8 are candidates for the long-term research partnerships. They have high potential, but the risks and costs are too high for RISO to bear alone (for example, fuel cell project). Quadrants 5,6,9 are poor candidates for any significant investment of time and money (such as spin out incubation): their potential is not enough to outweigh their risks. These opportunities should be made public via the “Invention digest”.

Finally, if technology looks interesting (quadrant 1 – 4), we must decide our next step. If there is a clear application already confirmed by business experts, we should, proceed to the product concept evaluation step, issue an innovation grant and then start working on the Proof-of-Concept. If we don't have strong applications yet, we should first conduct an application search.

Application search

Application search is the process of exposing new technical capabilities to a diverse pool of business experts in a hope that they will match the new technology with the business problems they are aware of. In this process, an innovation team, with the support from scientists, presents new technology to the team of business experts from various industries, facilitates discussions, and captures new product ideas. The quality of the product concepts generated by this process depends on the innovation team ability to:

1. Bring together a large, motivated, diverse and relevant pool of business expertise
2. Articulate new capabilities properly to non-scientists
3. Facilitate discussion and brainstorming process
4. Capture ideas and information
5. Efficiently rate ideas at the end of the process

Ability to create an effective pool of business expertise is the critical skill innovation team must develop. The size of the expert group should be large enough to ensure industry and functional diversity, and yet be manageable, perhaps up to 20 people. 1 or 2 places should be reserved for the researchers who can answer deep technical questions, 1 place - for the project manager who should manage the process, and 1 – for his assistant, designated to capture the meeting output. The remaining 16 places should be filled with the business experts from different industries and functions.

Deciding on who might provide a valuable input is more art than science. The odds of finding relevant people can be increased by using secondary market research (I recommend an excellent guide on identifying, accessing and motivating experts: "Find it Fast", by Robert Berkman, ISBN: 00627374730), and by involving already identified experts in brainstorming a list of people or organizations who might be valuable additions to the expert pool. Another approach is to announce a brief description of the new capabilities in the business network (by email), and solicit expert leads.

The expert panel should be diverse not only by industries, but also by functions. There are 2 categories of business experts - direct industry participants, and industry observers. The second category includes people who don't participate in the industry directly, but have significant exposure to its issues. This type of experts is important to have on-board: while direct industry participants might have deeper expertise, observers usually have more neutral and broader perspective.

Industry participants	Industry observers
▪ CEOs ▪ Top managers (VP business development) ▪ Founders, entrepreneurs ▪ Retired executives, ▪ Salespeople ▪ Customer service managers ▪ Purchasing managers ▪ Product development managers ▪ Heads of R&D, …	▪ Business school professors ▪ Industry consultants ▪ Commercial bankers ▪ Private investors ▪ VCs and buyout funds ▪ Industry analysts ▪ Investment bankers and business brokers ▪ Journalists and editors of trade magazines ▪ Industry association employees, …

Table 4: Example of expert types for an application-search session

The innovation team might also consider inviting participants whose involvement might have strategic value later in the process, such as entrepreneurs who might be interested in running the project, VCs who invest into the related technologies or industries, government officials, and so on.

The project manager should compile the list of the experts 2-4 weeks before the scheduled application search event. The list should be larger than intended audience, since some experts might not show up. The manager should contact experts personally and send them a teaser, which describes the purpose of the meeting, new technological capabilities, terms of engagement (including confidentiality and ownership of generated ideas). It should also provide incentives to participate: opportunity to see the new technology, networking with the other business experts, establishing relationships with the research institution, "innovation participation" publicity, priority options to invest, acquire license or start pilot projects, and so on. The invitation should also include logistics – location, time and duration of the meeting. The location should be convenient for most participants, and might not be located at the research institution. In this case, project manager must ensure that the location is properly equipped – it should have chairs, computer projector, writing paper, snacks and drinks, etc. For some experts, institute should offer to cover their travel expenses. Project manager must also ensure that participants have an opportunity to network. It will be helpful to prepare a list of participants with brief bios and share it in advance. Also, project manager should prepare badges with names/companies, and have everyone introduce themselves for 1-2 minutes at the beginning of the meeting.

After the introductions are made, project manager should make a 15-20 minute presentation, which should include the following:

- Objectives of the meeting
- Description of the new technology, its capabilities and limitations
- If possible, technology demo
- Overview of the meeting process
- Basic rules of brainstorming

To make this introduction productive, more detailed descriptions should be sent to the participants in advance, so that they had a chance to read and think about the possibilities. In addition, the presentation should be done by the project manager, not by the scientists, because researchers tend to be too technical and detailed for business audience. Rather, the scientists should handle technical questions and make demonstrations.

Then project manager should use a classic brainstorming process to facilitate the generation of new ideas. This process is well-known; I will only give 2 recommendations: first, add to the participants' badges <u>large</u>, easily visible numbers so that the assistant can capture who was the source of a particular idea. This information might be valuable for the idea evaluation later on. Second, to improve the efficiency, at least one of the project manager should be professionally trained as a group facilitator.

After the brainstorming session is completed, the participants should receive 5-7 sticker notes, and post them on ideas they think are the most practical and interesting. I recommend to put participant numbers on the stickers, so that they can be identified later. After the voting, the participants should have free time for networking. The project manager should close the meeting by thanking everyone, mentioning that the list of ideas will be compiled and shared by email, and that if anyone has additional ideas or want to initiate a project, they should contact the manager. Finally, it might be helpful to get a 1-page questionnaire to capture a feedback on how to improve the process and if participants will be willing to become a part of the innovation network and participate in similar events in the future. It is helpful to ask if they can recommend other experts who might be valuable for applying this new technology.

After the meeting, project manager should compile a written list of ideas, rank them by the number of votes, email the summary to the participants and allow several days to capture the follow-up feedback. The ideas then should proceed to the next step (see more in the "Innovation Report", page 32).

Question 3: How to implement this advice?

Step 1: Educate RISO officers in the invention classification. Review past patents, licenses, spin-outs. This exercise will train their intuition and provide interesting innovation statistics.

Step 2: Develop new “Technology Disclosure” and train scientists to fill it out. It might be helpful to take a couple of current and past cases first. Improve the disclosures until scientist have no problems understanding them and start providing high-quality, relevant information for technology evaluation.

Step 3: Design “Technology Evaluation Summary”, and try to fill it out based on the disclosures. See what additional information is necessary to make good decisions.

Step 4: Conduct a properly-designed Application Search session. Focus primarily on the expert group building, rather than on the facilitation process.

Step 5: Implement 2-tier “Invention Digest” system and start marketing already existing intellectual property.

Step 6: Re-design patenting to fit the new process.

Appendix 1: Invention disclosure

Date:	Researcher:
Disclosure #:	Title:

Invention description

Q1: Please describe of your invention briefly

Q2: Why do you think this invention is valuable?

Q3: Please describe your invention history:
- a) What sparked the invention idea? Was it a business problem you learned about, or your desire to improve an existing technology, or accidental discovery during your research, or something else?
- b) How long have you been working on the invention? What were the project major steps?
- c) Were other people from RISO involved? What were their roles? Who was the project leader?
- d) Were people or organizations outside RISO involved? What were their roles?

Technology

Q4: Please describe of your invention in details. Include diagrams, pictures, formulas, research papers and other materials to help us better understand how it works.

Q5: What are the key principles which made your invention possible? Please list them.

Q6: Can you demonstrate the proof of principle for your invention?
- a) If yes: please describe exactly what can be demonstrated currently
- b) If not, but you know how to build it: how long will it take you? What resources do you need?
- c) If not, and you don't know yet how: what are the key unsolved challenges? How much time do you need to resolve them? Please describe your ideas and plans for finding the solutions.

Q7: What were the most difficult problems you had to solve to make this invention? What are the most important achievements you made during this project?

Q8: How does your invention compare to the world level?
- a) What are the top 3 alternative solutions today?
- b) What are the key parameters to compare your invention to the alternatives?
- c) Please compare your solution to the alternatives on these key parameters
- d) What are the top 5 strongest research groups working on competing inventions? Do you know where they stand in their capabilities relatively to your invention?

Q9: What are the main advantages of your invention? What are the key trade-offs you resolved?

Q10: What are the main limitations of your invention? What are the key trade-offs you had to make?

Q11: What future improvements are possible? How do you envision the evolution of your technology?

Business

Q12: What are the possible applications of your invention?

a) Please list all existing (proven) applications you know
b) Separately, please list application ideas you might have

Q13: What do you think is the best first application for your invention?
a) Please explain why do you think it is the best? Do you have any business information which supports your choice?
b) What economic effect will your invention make for this application?

Q14: What is the business status of your invention?
a) Do you have already a business partner who wants to commercialize the invention?
b) Do you have any interest from the potential customers?
c) Have you shown your invention to any business experts and received their opinion?
d) Have you conducted any market research?
e) What other efforts have you made on the business side?

Intellectual Property

Q15: Is RISO the only legal owner of the intellectual property?
a) If not, please list who else has or might have legal claims on the ownership
b) Are there any other legal obligations related to this invention?

Q16: Is the invention patented? If not:
a) Have patent research been conducted? If yes, by who?
b) What are the key competing patents in this area which might deny our patent?
c) What are the key claims you would like to patent?

Project

Q17: How much time can you invest into the project to commercialize your invention?
a) None – you want to focus on your research
b) 100% - you want to leave your research and dedicate yourself to this project
c) If you want to balance research and this project: how many hours a week can you afford? Please attach a schedule with your availability for the next 6 months.

Q18: Will your department manager support your involvement into the project?

Evaluation assistance

Q19: Please list resources we can use to better understand your technology (books, tutorials, links, etc)

Q20: Please list names and contact information of any <u>scientific experts</u> who can provide independent opinion on your invention

Q21: Please list names and contact information of any <u>business experts</u> who can provide independent opinion on the market potential of your invention

Q22: Please list key patents which constitute prior art relevant to your invention

Q23: Please list any information sources which might help us find necessary information:
a) important research papers and scientific publications
b) articles in magazines and press
c) web links, databases, market reports, etc.

Q24: Please include anything else you think is important

Appendix 2: Opportunity Evaluation Summary

Date:	Manager:
Disclosure #:	Title:

Invention class

Level	PULL	PUSH
5		
4		
3		
2		
1		

If PUSH: Technology improvement

Relevant benchmark is selected	
Advance magnitude, %	

Number of applications

Known	
Potential	

Market risk stage

Non-expert product ideas only	
Expert product ideas	
Confirmed product opportunity	
Committed potential customer	

Technology risk stage

Solution idea only	
Proof of Principle demonstrated	
Product concept defined	
Proof of concept demonstrated	

Estimated time to Proof of Concept

< 3 months	
< 1 year	
< 3 years	
> 3 years	

Estimated budget to Proof of Concept

< $50 k	
< $100 k	
< $300 k	
> $300 k	

Project management

RISO must provide manager	
Entrepreneur is available	
Business partner is available	

Researchers time commitment (% project/research)

Research only, no project involvement (0/100)	
Mainly research, but will support project (20/80)	
Balance between project and research (50/50)	
Mainly project, but continue some research (80/20)	
Want to focus on project exclusively (100/0)	

Management support

Department manager approved	
Legal office approved	

Disclosure quality

% of questions with acceptable answers	
% of key facts verified by due diligence	

Recommended commercialization path

Can't decide, more information is needed	
Don't pursue	
Invention digest	
Licensee search	
Spin-out	

Decision confidence

Strong doubts, low confidence	
Mixed feelings	
Easy decision, confident	
Obvious decision, very confident	

Patent recommendation

Do not patent	
Wait for more information	
File provisional patent	
File full patent	

Risø's research is aimed at solving concrete problems in the society.

Research targets are set through continuous dialogue with business, the political system and researchers.

The effects of our research are sustainable energy supply and new technology for the health sector.